Pak. j. life soc. Sci. (2024), 22(1): 4751-4760 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.1.00350

RESEARCH ARTICLE

# Dry Law II and the Costs of the Unified Health System with Trauma for Motorcyclists

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***ARTICLE INFO***

Received: Apr 24, 2024

Accepted: Jul 3, 2024

***Keywords***

Unified Health System

Accidents

Traumas

Motorcycles

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**ABSTRACT**

The efficiency of the implementation of Dry Law II as a factor to reduce the costs of the Unified Health System linked to the care and treatment of motorcyclists and injured passengers for the historical series between the years 1998 to 2019 for the region Southeast Brazil. The research data were obtained from DATASUS, a database referring to admissions made through the AIH (Authorization for Hospital Admission) sent by SUS (Unified Health System) hospital units (public or private insured). The results found show a significant relation in the decrease of the average cost linked to the attendance of motorcyclists in the period after the implementation of Dry Law II for the analyzed states. The control variables in this study did not show a significant relationship. Regardless of the behavior of the motorization and motorcycles, they did not have a relationship in reducing the average hospitalization costs.

## INTRODUCTION

The number of traffic deaths has been showing steady growth rates around the world. According to data from the World Health Organization (WHO) in 2016, there were approximately 1.35 million traffic deaths worldwide. (1)

In 2015, the Institute for Applied Economic Research (IPEA) released the research report with the estimate of costs linked to accidents on highways in Brazil for the previous year. In 2014 there were 167,247 accidents on the Brazilian federal highways, with 8,233 deaths and 26,182 serious injuries, generating a cost of R $ 12.8 billion to society, 62% of which was associated with the victims, such as: hospital expenses , care, treatment of injuries, removal of victims, loss of production (how much income does a traffic victim fail to earn, both during the period when he is away from economic activities and, in the case of death, in relation to his expectation life) and the rest associated with vehicles and property damage.(2)

Data from the Ministry of Health's Health Situation and External Causes Analysis Report for the year 2013 shows that 21% of deaths from external causes, being a set of various forms of violence and accidents, occurred due to traffic accidents, being of this total, 35.3% of deaths affected by motorcyclists.(3)

Exposure to the risk of traffic accidents is directly linked to the behavior and prudence on the roads. Speeding, non-compliance with laws, combination of alcohol and driving, are the main causes of traffic accidents in Brazil. About 70% of violent accidents with deaths on Brazilian roads make alcohol the main responsible.(4)

Based on the above, this work has as its theme the study of the efficiency of the implementation of Dry Law II (Law nº 12.760 of 12/20/2012)(5) as a factor to reduce the costs of the Unified Health System linked to the care and treatment of motorcyclists and injured passengers for the historical series between the years 1998 to 2019 for the Southeast region of Brazil, comprising the states of the Southeast Region, that is, Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo.

With the assumption of a drop in the number of accidents, it is expected that the null hypotheses, H0, initially proposed will be rejected and the costs of hospitalization before the law will be different from the costs of hospitalization after its implementation.

## MATERIALS AND METHODS

This study presents itself as qualitative research. To test the efficiency of the implementation of Dry Law II as a public policy capable of reducing the average total costs of SUS hospitalizations with motorcyclists, between the years 1998 to 2019, the V20 to V29 classifications of the 10th Revision of the International Classification of Diseases (ICD-10) (6) in Hospitalization Authorizations (AIH) in a public database available on DATASUS(7) for the Southeast region of Brazil.

The study was divided into two periods, namely:

0.1998 to 2012, period before the implementation of Dry Law II

1.2013 to 2019, period after the implementation of the Dry Law II

Evaluating the periods with the hypotheses:

A. H0 hypothesis: costs of hospitalization before Dry Law II are equal to the costs of admission after Dry Law II.

B. Hypothesis H1: Hospitalization costs before Dry Law II are different from the costs of admission after Dry Law II.

The research data were obtained from DATASUS (7), a database referring to admissions made through the AIH (Authorization for Hospital Admission) sent by SUS hospital units (public or private insured). From the combination of samples from the chosen states, the variables Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo were created for each one of them, assuming 1 for their respective data.

As variables of control of this study, the evolution of the road network and the motorization and motorcycles indices on the Brazilian traffic roads were made available in the 2019 Yearbook of the National Transport Confederation (CNT) of 2019 (CNT, 2019) and of the National Department of Transit,(8) respectively.

The analyzes of this work were made with the aid of the statistical software Microsoft Excel™ and Stata™. Due to limitations of version 14 of the Stata™ software, used in this study, the values of the motorization and motorcycles variables had their values adjusted for a ratio of 1000, receiving names respectively for Motorization and Motorcycles. The adjustment made will not affect the statistical analysis provided by the software.

Initially, statistical inference analyzes were used in the total data set and segmented by state. Hoffmann (2006) (9) defines the value for the arithmetic mean as:

$$\bar{X} = \frac{1}{n}\sum_{1=1}^{n} Xi$$

Where *n* is the total amount of data in the set and *Xi* is any value in the data set in position *i*.

To analyze the uniformity of the data set, standard deviation was used as a measure for this. Hoffmann (2006) defines the value for the standard deviation as:

$$Dp = \sqrt{\frac{\sum_{i=1}^{n}(Xi - \bar{X})^2}{n}}$$

Where $Xi$ is any value in the data set in position *i*, $\bar{X}$ the arithmetic mean of the sample and n the total amount of data in the set.

These tools will provide support to analyze the behavior, uniformity and central tendency of the sample averages of the total sets, with 88 observations, and segmented by state, each with 22 observations, between the years 1998 to 2019.

To test the linear association and the relationship between the mean AIH, Prohibition, Motorization, Motorcycles and Road mesh variables, Pearson's correlation coefficient was used, as being [10,11]:

$$r = \frac{\sum_{i=1}^{n}(Xi - \bar{X})(Yi - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(Xi - \bar{X})\sum_{1=1}^{n}(Yi - \bar{Y})^2}}$$

Where $Xi$ is any value in the data set at position i and $\bar{X}$ the arithmetic mean of the sample and the total amount of data in the set for variable X. The values of Yi are any value in the data set at position i and $Y$ a arithmetic mean of the sample and the total amount of data in the set for variable Y. The correlation matrix is arranged as:

$$r = \begin{pmatrix} 1 & r_{12} & \cdots & r_{1n} \\ r_{21} & 1 & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & 1 \end{pmatrix}$$

The values assumed by Pearson's coefficient are classified as:

$r_{xy} = -1$, a perfect negative correlation;

$-1 < r_{xy} < 0$, a negative correlation;

$r_{xy} = 0$, being a null correlation;

$0 < r_{xy} < 1$, positive correlation;

$r_{xy} = 1$, perfect positive correlation.

By segmenting the available bases between periods 0, before the implementation of Dry Law II between the years 1998 to 2012, and period 1, after the implementation of Dry Law II between the years 2013 and 2019, it was possible to apply the Test statistics Nonparametric T with a 95% one-tailed confidence interval in order to compare whether the average cost of AIH in period 1 is greater than the average of this variable for period 0. Hoffmann (2006)[9] defines the t test as being:

$$t = \frac{\overline{X1} - \overline{X0}}{\sqrt{\frac{\overline{X1} - \overline{X0}}{\sqrt{\frac{(DpX1)^2}{n1} + \frac{(DpX0)^2}{n0}}}}}$$

Where, $\overline{X1}$ is the sample arithmetic mean, $DpX1$ the sample standard deviation and $n1$ the sample size for the analysis variable in period 1. The value $\overline{X0}$ is the arithmetic mean of the sample, $DpX0$ the sample standard deviation and $n1$ the sample size for the analysis variable in period 0. Where the test hypotheses are:

H0: the arithmetic means of the variables are the same;

H1: the arithmetic means of the variables are different.

To complement the analyzes, a robust panel of heteroscedasticity was made for the analysis variables. The variables created for each of the states of the Federation received values 0 or 1 as references for the data of each one of them, so that the use of all of them would generate problems of multicollinearity between them. Thus, the state of São Paulo was excluded from the model, being reconstructed derived by the other states.

This research has no conflicts or ethical aspects, which is why it is not necessary to present and approve it before the institution's ethics committee.

## RESULTS

In this work, we test the efficiency of Dry Law II as a factor for reducing the average costs linked to hospitalizations of motorcyclists and passengers to the states of the Southeast region of Brazil. Initially, a database was created with information from all states in order to analyze descriptive statistics displayed 1 with 88 observations.

| Variable | Obs. | Average | Standard deviation | Mín. | Máx. |
|---|---|---|---|---|---|
| AIH | 88 | 1.998,72 | 427,16 | 1.009,620 | 3230,20 |
| Motorization | 88 | 7.783,08 | 7819,62 | 295,00 | 30059,00 |
| Motorcycle | 88 | 1.436,95 | 1515,94 | 19,00 | 5771,00 |
| Road network | 88 | 132.987,50 | 108.944,60 | 24.856,90 | 280355,20 |

The average AIH variable has its average for the evaluated states of R$ 1,998.73, standard deviation of R$ 427.16 and has its values between the minimum of R $ 1,009.62 and maximum of R$ 3,230.20, being respectively referring to the states of Espírito Santo in 2018 and Minas Gerais in 2009.

Motorization has its average for the evaluated states of 7,783.08, standard deviation of 7,819.63 and values between a minimum of 295 and a maximum of 30,059, being respectively for Espírito Santo in 1998 with 294,852 vehicles in circulation and São Paulo for the year 2019 with 30,058,975 vehicles in circulation.

The motorcycle index has its average for the evaluated states of 1,436.96, standard deviation of 1,515.94 and minimum values of 19 and maximum of 5,771, being respectively for the States of Minas Gerais in 1999 with 19,179 motorcycles in circulation and São Paulo for the year 2019, with 5,771,031 motorcycles in circulation.

The road network, on the other hand, has an average extension for the evaluated states of 132,987.5 km, a standard deviation of 108,944.60 km and values between a minimum of 24,856 and a maximum of 280,355.20 km, respectively for Rio de Janeiro for the year. 2002 and Minas Gerais in the year 2017.The descriptive statistics segmented for each of the states is listed in the tables below:

Minas Gerais was the state with the highest average for the average AIH variable in the years evaluated, with R$ 2,271.74, a value of R $ 273.01 higher than the average of all states combined (Table 1). The state with the lowest average for the variable was Espírito Santo with R$ 1,687.98, R $ 310.75 less than the average for all states combined (Table 2). The state with the highest standard deviation for the variable was Minas Gerais, with R$ 479.10. The state with the lowest standard deviation was Rio de Janeiro, with R$ 259.34 (Table 1).

In relation to the motorization index, the State of São Paulo has the highest average with 19,038.45, representing 19,038,450 vehicles in circulation for the years evaluated (Table 1). The State of Espírito Santo has the lowest average in the years evaluated, 1,150.96, representing 1,150,955 vehicles in circulation. The lowest standard deviation found for the variable was also in Espírito Santo, with 547.72. The largest standard deviation for the variable is in São Paulo with 6,971.96.

The highest average for the variable of motorcycles in circulation in the years evaluated was 3,267.68 in the State of São Paulo, representing 3,267,682 motorcycles in circulation. Minas Gerais has the lowest average number of motorcycles in circulation, being 300.59, representing 300,590 motorcycles in circulation. The largest standard deviation found for the variable was 1,706.92 in São Paulo, while the smallest standard deviation is in Espírito Santo, being 185.96.

For the road network in the years evaluated, the highest average found for the years of analysis was in the state of Minas Gerais with 277,296.4 km. The State of Rio de Janeiro has the lowest average for this variable with 25240.72 km. Regarding the standard deviation, the state with the highest level is 204.92 km. The largest deviation found for the variable is in Minas Gerais with 2246.50 km.

To assess the average behavior of the AIH, we used the base constituted with all the states separated in two moments: period 0 being before the implementation of Dry Law II, 1998 until 2012, and period 1 being after its implementation, 2013 until 2019. The statistics descriptive of both moments is shown in figure 1.

The descriptive statistics for the average AIH variable shows that the average value after the implementation of Prohibition II is R$ 1,674.05, compared to an average of R $ 2,150.25 before the implementation of Prohibition, a value of R$ 476,20 smaller. After the implementation of Dry Law II, the standard deviation was also lower compared to its implementation. The maximum and minimum values after the implementation of Dry Law II were also lower in the second period evaluated.

In order to describe whether there is a correlation between the variables in the analysis set, a correlation matrix was used, figure 2.

The correlation matrix shows a negative and significant relationship between the mean AIH and Prohibition variables of -0.5222. The variables Motorization and Motorcycles have an index of 0.7837, showing to be very correlated. Thus, the Motorization variable was used as chosen to be tested on the robust heteroscedasticity panel.

As a complementary method for analyzing the averages of the AIH found in both evaluated periods, the one-tailed T test was used in order to show whether the values of period 1 are greater or less than period 0. The test statistics are shown below:

| **Group Obs** | **Average** | **Std. Err.** |
|---|---|---|
| 0 60 | 2150,247 | 50.62929 |
| 1 28 | 1674,046 | 57.17384 |
| T Test | P – valor 0.000 | |

The test points out that there is a significant difference between the averages for periods 1 and 0, converging with the results of the descriptive statistics found. Thus, the H0 hypothesis defined in this work, confirming the H1 hypothesis, where the costs found for the samples segregated by the Prohibition variable are different.

The robust panel model of heteroscedasticity omitting the variable of the State of São Paulo with the dependent variable average AIH being explained by the variables Dry Law II, Motorization, Road network and controlled by the states of Espírito Santo, Minas Gerais and Rio de Janeiro is shown in the table 2 below:

The robust model shows how it evidences a relationship between Dry Law II as a factor of reduction of the average cost of AIH, confirming again the hypothesis H1 presented. The other variables used in the model are not related to the average cost of hospitalization, such as mesh and motorization, where empirically expected a relationship between them and the average cost of AIH.

The one-tailed T test was also applied to the samples segmented by each of the states in periods 1 and 0 in order to know the behavior of the AIH averages, and is shown in the figure 3.

The tests applied in the sets for the samples segmented for all the states of analysis also corroborate the H1 hypothesis presented in this work, where all the averages found for periods 1 and 0 are different, rejecting the delimited H0 hypothesis again, showing that the Prohibition Law, among the listed control variables, it is shown to be relevant as a factor of decrease in the average cost of AIH.

**DISCUSSION**

According to Lopes (2008)[12] it is the duty of the State to act and develop actions on different fronts, such as health, education and the environment, to achieve results and promote the well-being of society, using public policies for this.

In order to provoke an aversive behavior of the binomial alcohol and driving, the Brazilian government brought in 2008 the first version of Prohibition. This law emerged as an alternative of public policy of the Brazilian State to stop the increasing numbers of traffic accidents, aiming to punish drivers who drive under the influence of alcohol, having in a second moment being reviewed and having their punishments more rigid in order to have greater efficiency.[5]

Data available on DATASUS show that in the month of July 2017 and July 2018, that is, before and after Dry Law II, show that the number of road traffic fatalities decreased by 12.9% compared to the dates, and the rate of mortality related to external causes showed a reduction of 10.8% taking into account the gross rate of the population in the period.[13]

In 2018, 10 years after the implementation of the first version of Dry Law II, data from the Ministry of Health show the positive impacts of the law on changing driver behavior with a 2.4% reduction in the number of deaths from traffic accidents in relation to the year 2008.[14] The reduction is even more representative when compared to the year 2012, when the law underwent its first amendment, becoming more rigid with the increase of the fine for drivers caught driving drunk. In 2012, 44,812 people died from traffic accidents. Compared to 2016, there was a reduction of 16.7%.[14]

Studies by the Ministry of Health show that despite the drop in the number of deaths after the implementation of Dry Law II, there was a significant increase in the number of hospitalizations. This study shows that in 2008, there were 95,216 hospitalizations in the Unified Health System (SUS) involving drivers, passengers and pedestrians victims of traffic accidents, compared to 181,120 hospitalizations in 2018 in the same classification, an increase of 90.2%, generated an expense greater than R$ 252.7 million.[14]

In 2014, 176,007 hospital admissions were recorded by ATT (rate of 8.6 hospitalizations/10,000 inhabitants), with motorcyclists being the main victims among deaths (28.9%) and hospitalizations (54.7%).[15]

According to Neves et al. (2015)[16] Dry Law II in its first moment brought benefits to citizens, causing a reduction in the total costs of hospitalization after implementation when assessing the context of the whole of Brazil and all the traumas caused by automobile accidents, however failing to relate a positive effect in the study of effectiveness in its second period of effectiveness.

From the collection of information and statistical analysis of the samples of interest in this work, it can be concluded that Dry Law II proved to be efficient as a relevant factor in reducing the average costs of AIH. This same result was observed when using all samples from the Southeast region and when segmented taking into account the analyzes segmented by States.

The tests applied to the sample also point out that the control variables such as motorization index and motorcycles on land roads have no importance in explaining the behavior of the average AIH in periods 0, before the implementation of Dry Law II, and 1 after its implementation. This implies that regardless of the mesh size or motorization and motorcycle indexes, the values found do not have a significant correlation.

Despite scarce studies on the effectiveness of Dry Law II as an efficient public policy factor on Brazilian roads, there is much room for research in this regard. The duality of alcohol and driving is responsible for a significant part of road traffic accidents, not only in Brazil, but afflicting several countries around the globe.

In this sense, it is suggested as possible future studies to test the efficiency of this law for other Brazilian regions with the same approach used in this work of motorcycle occupants as a significant factor in reducing the average costs of AIHs, or also as costs for education and awareness raising. of road occupants and their practical effect on the costs or numbers of accidents involving drivers.

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## TABELAS, QUADROS E FIGURAS

**Table 1: Descriptive statistics for the state of Minas Gerais, Espirito Santo, Rio de Janeiro and São Paulo considering samples from periods 0 and 1**

| Variable | Obs. | Average | Standard deviation | Mín. | Máx. |
|---|---|---|---|---|---|
| State of Minas Gerais | | | | | |
| AIH | 22 | 2.271,74 | 479,10 | 1.531,60 | 3.230,20 |
| Motorization | 22 | 6.630,13 | 2.989,25 | 2.801,00 | 11.728,00 |
| motorcycle | 22 | 300,59 | 185,95 | 19,00 | 574,00 |
| road network | 22 | 277.296,40 | 2.246,49 | 272.801,50 | 280.355,20 |
| State of Espírito Santo | | | | | |
| AIH | 22 | 1.687,97 | 399,04 | 1.009,62 | 2.309,84 |
| Motorization | 22 | 1.150,95 | 547,72 | 295,00 | 2.011,00 |
| motorcycle | 22 | 1.586,50 | 895,51 | 382,00 | 2.906,00 |
| road network | 22 | 31.566,65 | 204,92 | 31.292,10 | 31.883,00 |
| State of Rio de Janeiro | | | | | |
| AIH | 22 | 1.890,49 | 259,33 | 1.471,38 | 2.546,46 |
| Motorization | 22 | 4.312,77 | 1.634,89 | 2.013,00 | 6.951,00 |
| motorcycle | 22 | 593,04 | 370,12 | 99,00 | 1.172,00 |
| road network | 22 | 25.240,72 | 289,77 | 24.856,90 | 25.519,90 |
| State of São Paulo | | | | | |
| AIH | 22 | 2.144,69 | 293,35 | 1.551,20 | 2.590,78 |
| Motorization | 22 | 19.038,45 | 6.971,96 | 8.857,00 | 30.059,00 |

| | | | | | |
|---|---|---|---|---|---|
| motorcycle | 22 | 3.267,68 | 1.706,92 | 835,00 | 5.771,00 |
| road network | 22 | 197.846,00 | 2.046,18 | 195.405,30 | 200.871,10 |

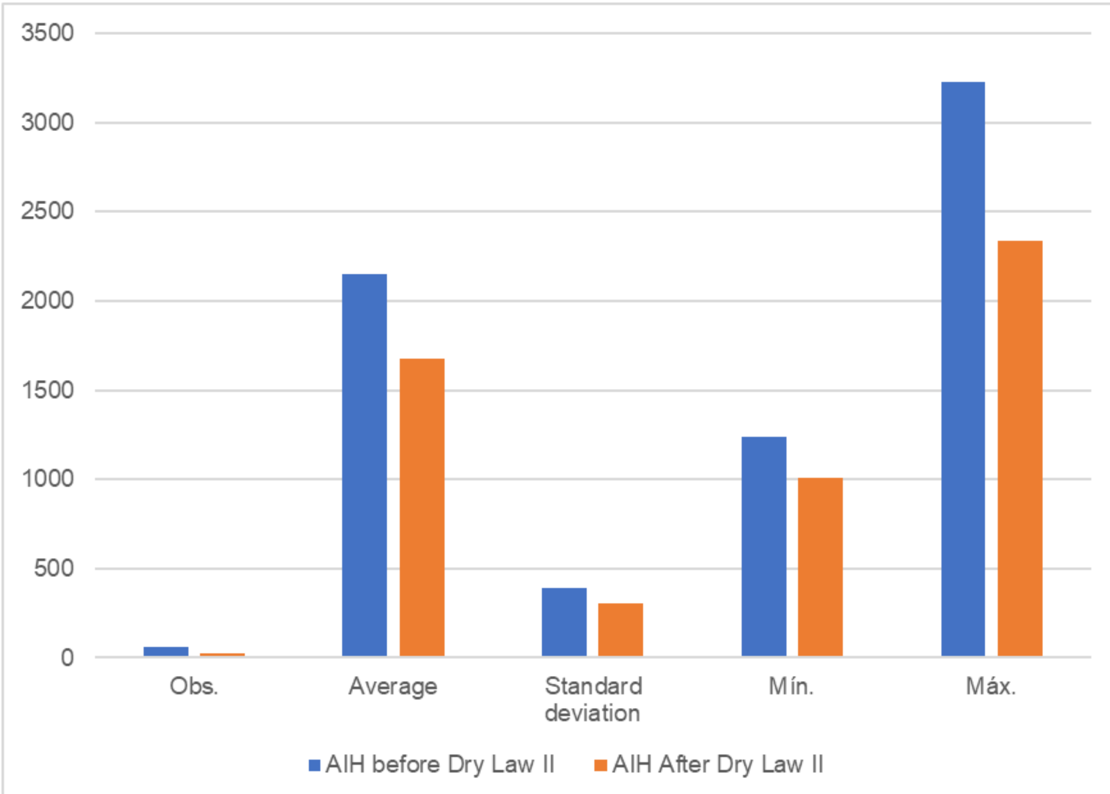


**Figure 1: Descriptive statistics of the average AIH for all states evaluated in period 0, before the implementation of the Dry Law II.**

| | *AIH* | Dry Law II | Motorization | Rotorcycle | Road Network |
|---|---|---|---|---|---|
| **AIH** | 1 | | | | |
| **Dry Law II** | -0,522 | 1 | | | |
| **Motorization** | 0,143 | 0,3219 | 1 | | |
| **Motorcycle** | -0,1851 | 0,4145 | 0,7837 | 1 | |
| **Road Network** | 0,4998 | 0,0007 | 0,4774 | 0,0454 | 1 |

**Figure 2: Correlation matrix of the variables in the analysis set considering samples from periods 0 and 1.**

**Table 2: Robust panel of heteroscedasticity applied to the analysis variables considering samples from periods 0 and 1, with R-square: 61,33%.**

| AIH | Coef. | Std. Err. | P-Valor |
|---|---|---|---|
| **Dry Law II** | -534,596 | 88,36981 | 0.000 |
| **Motorization** | 0,010777 | 0,011881 | 0.364 |
| **Road Network** | 0,003058 | 0,026356 | 0.908 |
| **Dummy States** | | | |
| **_Const.** | 1504,53 | 5021,84 | 0.764 |

| State of Minas Gerais | | | |
|---|---|---|---|
| **Group** | **Obs** | **Average** | **Std. Err.** |
| **0** | **15** | 2453,005 | 114.5266 |
| **1** | **7** | 1883,326 | 110.9483 |
| **P-Valor** | | 0.0030 | |

| State of Espirito Santo | | | |
|---|---|---|---|
| **Group** | **Obs** | **Average** | **Std. Err.** |
| **0** | **15** | 1857,342 | 88.22414 |
| **1** | **7** | 1325,044 | 92.20114 |
| **P-Valor** | | | 0.0007 |

| State of Rio de Janeiro | | | |
|---|---|---|---|
| **Group** | **Obs** | **Average** | **Std. Err.** |
| **0** | **15** | 2000,487 | 62.70488 |
| **1** | **7** | 1654,807 | 19.72979 |
| **P-Valor** | | | 0.0007 |

| State of São Paulo | | | |
|---|---|---|---|
| **Group** | **Obs** | **Average** | **Std. Err.** |
| **0** | **15** | 2290,153 | 51.99115 |
| **1** | **7** | 1833,006 | 75.93646 |
| **P-Valor** | | | 0.0000 |

**Figure 3: T test applied to the state of Minas Gerais, Espirito Santo, Rio de Janeiro and São Paulo separating samples from periods 0 and 1.**